Small-scale Forestry (2013) 12:67–85
DOI 10.1007/s11842-012-9205-3

RESEARCH PAPER

From Farmers to Loggers: The Role of Shifting Cultivation Landscapes in Timber Production in Cameroon

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Accepted: 1 March 2012 / Published online: 29 March 2012

Abstract This article focuses on timber sourced from the agricultural areas in the shifting cultivation landscapes of the Central Region of Cameroon. Data about volumes marketed in urban centres, harvesting operations and on-farm timber management are used to discuss the ecological impact of small-scale logging and its sustainability in the long term. An opportunistic association exists between small-scale logging and agricultural land uses, determined mostly by the abundance of valuable species in fallows and on cocoa farms, their easy accessibility and the low price of farmland timber. Farmers apply various strategies to the management of tree resources in fallows and cocoa agroforests, with most felling authorized in fallows and most trees preserved on the cocoa farms. With current agricultural expansion and intensification trends associated with small-scale logging, timber resources on rural land are at risk of depletion with direct consequences for domestic timber supply and the thousands of livelihoods it sustains. Marketing and regulatory changes are needed to encourage the integration of timber production in agricultural management systems.

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Keywords Small-scale logging · On-farm timber · Fallow management · Cocoa agroforests · Farmers' livelihoods · Domestic timber sector

Introduction

Domestic timber markets increasingly appear as relevant issue to consider when designing strategies that target legal and responsible forest management in tropical timber producing countries. Case studies in West and Central African countries (reported by Hansen and Treue 2008; Cerutti and Lescuyer 2011; Lescuyer et al. 2011) indicate that informal small-scale logging for the domestic timber market is the main cause of illegal timber harvest. Small-scale logging,[1] that takes place outside the legally gazetted production forests in what is generally termed the non-permanent forest estate (NPFE),[2] constitutes the mainstay of total timber production in Ghana, Cameroon, the Democratic Republic of the Congo and Liberia and a high percentage in the Republic of the Congo and the Central African Republic. Research on small-scale logging has to date largely focussed on the economic and social implications, highlighting the accrued benefits for rural and urban people, in particular in terms of local employment and reduction of rural poverty (e.g. see Marfo 2010; Cerutti and Lescuyer 2011; Hansen 2011; Lescuyer et al. 2011). Less attention has been paid to the ecological impacts of unregulated artisanal timber harvesting in the NPFE.

Cameroon is a paradigmatic example of the importance of informal artisanal logging in supplying a booming domestic timber market. Over the last decade, national domestic timber consumption almost tripled, reaching about 660,000 m^3 of sawn wood in 2009, exceeding the official industrial production (Cerutti and Lescuyer 2011). The most marketed species are the same as those exploited by the industrial sector, in particular ayous (*Triplochiton scleroxylon*) and iroko (*Milicia excelsa*). Artisanal sawn wood is mostly used in urban construction and carpentry, which have high demand—in particular for ayous—for low-quality beams and planks for scaffolds and formwork (JMN 2005). About 80 % of the estimated production is traded in the capital city, Yaoundé (Cerutti and Lescuyer 2011). Given the limited financial resources of the small-scale logging operators and the low value of the products marketed, transport costs strongly influence the choice of supply areas. Artisanal sawn wood is largely sourced in the in the NPFE of the Central Region (Plouvier et al. 2003; JMN 2005), in particular from the rural landscape mosaic (as defined by Forman and Godron 1986) created by smallholders' agricultural practices based on shifting cultivation. Ranging from subsistence to fully market-oriented production, shifting cultivation consists of the periodic spatial shift of cultivation to newly cleared forest or fallow land that is sufficiently fertile to support crop production (McGrath 1987) and creates a mosaic of land use units

[1] Small-scale logging is defined as the artisanal chainsaw milling of selected trees that are then processed into planks on the felling site and manually transported and piled along access roads (described by Auzel et al. 2001).

[2] For a review of national case studies of artisanal logging in the NPFE, see Wit et al. (2010).

among which are farms, fallows[3] of various ages and secondary and old growth forest remnants (Finegan and Nasi 2004; Robiglio and Sinclair 2011). Small-scale logging operators negotiate with farmers the sale of timber trees standing on the land they own under the customary tenure system. Despite the importance of the timber sourced from the rural mosaic, no quantitative information exists on the amount harvested and on the land use units where the timber is felled.

In 2010 Cameroon signed a binding trade agreement with the European Union (a Voluntary Partnership Agreement, VPA), committing to legally source all national timber production by 2013. Small-scale logging permits in the 1994 *Forestry Law* (République du Cameroun 1994, Law No. 94/01)—including the timber exploitation permits[4], and Community Forests[5] (Nzoyem et al. 2010; Smith 2010; Lescuyer 2011)—have not proven cost-effective in competing with informal artisanal sawing that has continued to proliferate in the NPFE (Auzel et al. 2001; Cerutti and Lescuyer 2011). Hence, a reform of current regulations to develop and increase transparency in the national timber sector is currently being considered, including measures to bring small-scale chainsaw milling and trading activities into the formal sector. Whether and how far timber resources in the NPFE may sustain logging by artisanal sawyers and the demand by the domestic timber market is an important issue to address.

Little meaningful information exists on timber stocks in the shifting cultivation landscapes of Southern Cameroon. Estimates based on National Forest Inventory data (FAO-MINFOF 2007) indicate that about 27.6 and 33.1 M m^3 of exploitable timber are available on perennial cropland (cocoa and coffee) and on fallow land (young secondary forest). This timber stock originates from the tradition of preserving multi-purpose trees at the moment of field preparation (Dounias 1993; Carrière 1999), and from natural regeneration of forest species in the fallow rotations (Carrière et al. 2002; Robiglio and Sinclair 2011). The stock includes highly valuable indigenous timber species including ayous, iroko, frake (*Terminalia superba*), dabema (*Piptadeniastrum africanum*), sapelli (*Entandrophragma cylindricum*) and tali (*Erythrophleum ivorense*). All have higher densities in the fallow-based systems (annual crops and fallow units) than in the perennial crops. More detail on the most marketed timber species in Cameroon is provided in Appendix 1.

[3] Fallows are the primary component of shifting cultivation systems. Ecologically they are defined as complexes of secondary vegetation at various reconstitution phases, regenerating after the clearing of forest for agriculture (FRA 1998). They are important for the restoration of soil fertility after cropping, for weed control and for sustaining the livelihoods of households through a number of edible, drinkable, medicinal and timber products (Burgers et al. 2000).

[4] Timber exploitation permits are issued by the Ministry of Forestry and Wildlife to registered operators for up to 1 year and a maximum volume of 500 m^3.

[5] A Community Forest is defined as 'a forest forming part of the NPFE, which is covered by a management agreement between a village community and the Forestry Administration'. It can have an area of up to 5,000 ha. All forest products from community forest management belong solely to the village communities concerned and can be traded. The community enjoys the use of the forest according to a Simple Management Plan that stipulates the beneficiary community, the CF boundaries and its main uses, a description of the forest, the operating program and forest and wildlife management instructions. The management plan lays the foundations for the management agreement between community and Ministry; it is usually planned for 25 years and must be revised every 5 years.

Little is known about their local distribution, because most of the local inventories of farmland tree resources have focussed on the production of non-timber forest products (NTFP), biodiversity assessments and carbon stock measurements (Kotto-Samè et al. 1997; Van Dijk and Wiersum 1999; Zapfack et al. 2002; Sonwa et al. 2007; Robiglio and Sinclair 2011).

The present study sought to provide initial basic information about small-scale timber exploitation in the NPFE, to inform policy decisions and identify useful future research directions. Specific objectives were to estimate (1) the volume of timber sourced from rural areas, (2) the relative importance of the land-use units that form the rural mosaic in supplying timber, and (3) the availability of timber trees by land-use types. The study was also designed to investigate (1) the management practices of timber trees in the various land-use systems, (2) the relationship between timber harvesting and agricultural practices, and (3) farmers' perceptions about timber exploitation by artisanal sawyers on their own land.

The Study Area

The study was conducted in the Central Region of Cameroon due to its dominant role in supplying timber for domestic uses (as reported by Cerutti and Lescuyer 2011), its vast areas of farmland and of NPFE,[6] and the high density of rural transport networks that facilitate access to on-farm timber resources (Ministry of Public Works 2011).

The Central Region stretches from latitude 3°5′–6°16′ North, over an area of about 6.8 M ha. It embraces the border region between the North Western Congolian Lowland Forest and the Northern Congolian Forest-Savannah Mosaic ecoregions (Olson et al. 2001). The dense semi-deciduous, mixed semi-deciduous and evergreen degraded forest types occupy about one third of the total land and dominate in the southern part (Fig. 1).

The Central Region is the most densely populated area in southern part of Cameroon, with 58.8 % of the population living in Yaoundé, the regional and national administrative capital. In the last 35 years the population of Yaoundé has risen dramatically from 313,000 to 1.8 M inhabitants (BUCREP 2010), with an annual growth rate of 5.7 % between 1987 and 2005.

Less than half of the forest area in the Central Region is Permanent Forest Estate (PFE). The rest, about 1.4 M ha, according to authors estimates (see footnote 3), is open to logging under short-term logging permits, designed either for industrial, export-oriented exploitation such as sales of standing volumes and timber recovery authorizations, or for legal small-scale logging operations based upon exploitation permits or from Community Forests.[7]

[6] The extent of the NPFE was calculated by the authors by subtraction, superposing in ArcGIS9.3 the Permanent Forest Domain map from GFW (GFW 2008) to the OFAC land cover map. The extent of the transport network was assessed using the spatial dataset of the Ministry of Public Works (2011).

[7] Thirty Community Forests were operating in the region in 2010, with an estimated annual maximum timber production of about 22,000 m^3. No official data exist on logging permits issued in the region.

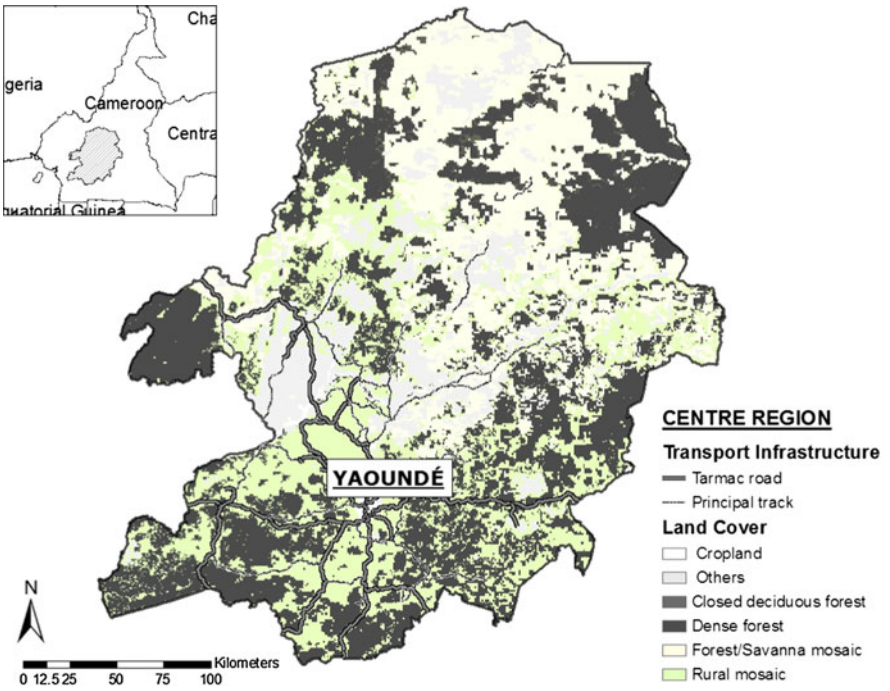

Fig. 1 The study area, Centre region, Cameroon. The land cover map was derived from OFAC et al. (2008)

Forested land in the NPFE not allocated to formal logging activities is available for the local populations to exert their customary user rights; these include to harvest timber and non-timber forest products for own-consumption but exclude any form of trade (République du Cameroun 1994, Law No. 94/01). Local populations may clear the forest to establish new farms according to the pre-colonial systems of land-access rights, as described by Diaw (1997).

In the Central Region the rural land covers about 1.9 M ha (Fig. 1). About 330,000 ha are occupied by annual crops cultivated on a fallow-based rotation (Ministry of Agriculture and Rural Development 2009) and about 1.2 M ha by fallows, assuming an average fallow length of 4 years based on Tiki-Manga and Weise (1995). As shown by statistics on agricultural surfaces for 2007–2008, farmers in the Central Region are turning towards new cash crops including pineapple (an increase of 1 % for the year), tomato (4 %), and cassava (10 %), maize (13 %) and plantain (15 %) grown in monoculture, as opposed to the traditional mixed extensive systems (Ministry of Agriculture and Rural Development 2009). Agricultural intensification entails changes in the spatial configuration of the rural mosaic. These include the conversion of land dominated by tree fallows with scattered cultivated fields, into land dominated by young herbaceous fallows interspersed with clustered fields, and also the expansion and merging of the young fallow land that increases the isolation of the forest fragments (Robiglio and Sinclair 2011).

The Central Region is the second most important for cocoa production in Cameroon after the South West. Cocoa farms occupy about 180,000 ha. After a decade of decline, the cocoa sector is experiencing a relative revival, favoured by increasing cocoa prices and government investments to restructure the sector. With the goal of doubling national production by 2015, sun-loving high-productive hybrids with earlier and higher productive peak yield are distributed by SODECAO (Société de Développement du Cacao) at a rate of 6 M plants per year (Republic of Cameroon 2009).

Research Method

To estimate the volume of timber sourced in the rural areas and identify the land-use units where it is harvested a sub-set of data was used collected in 2009 by two of the authors for a study on the domestic timber market in Cameroon by two of the authors (see Cerutti and Lescuyer 2011 for a detailed description of the methodology). The sub-set included:

(1) market data for timber products originating from the Central Region per species, from 24 markets in Yaoundé over the period June 2008 to July 2009 (for a total of 17,975 selling operations observed), and
(2) data on 151 logging operations in 21 councils in the Central Region. Data included species, land-use type where the operations were undertaken, and costs incurred by the small-scale loggers.

An additional exploratory survey was conducted in 12 villages in 6 of the 21 council territories. These were selected based on the advice of local forest authorities concerning small-scale chainsaw milling activities in each locality. A semi-structured questionnaire was first addressed to the village chiefs, providing a rapid appraisal of the village characteristics and logging activities on village land. A second questionnaire was addressed to 78 household heads[8] identified by the village chiefs as being involved in on-farm timber marketing. The survey covered farmers' perceptions about timber resource availability on their farmland and the quality of natural regeneration per species, as well as the role of timber trees in land-use units, and farmer' management, harvesting and trading practices (Table 1).

Informal discussions were carried out at the end of each interview to elicit farmers' experiences and perceptions about small-scale logging in relation to the legal framework, tree tenure, market demand for timber and the financial value of trees.

Data were analyzed quantitatively, by simple descriptive statistics and frequencies using Microsoft Excel 2007.

Results

Overall 34 species originating from the Central Region were traded in Yaoundé, with an estimated annual volume of about 510,000 m^3, 75 % of the total volume traded in

[8] A household is defined here as a unit formed by a married person, their unmarried children and other adult family members who share the same residence.

Table 1 Topics covered and description of the information collected in the exploratory study

Village characteristics	Legal logging activities (present and past)
	Presence and origin of artisanal chainsaw operators
	Local availability of logging equipment
	Markets supplied
Timber tree species inventory per land-use units	Inventory of household farmland[a]
	Distribution of exploitable trees[b] by species
	Distribution of small trees by species
	Qualitative assessment of availability trends by species
Timber sale over the last 5 years per land-use unit	Number of trees
Timber tree management per land-use unit	Species purpose
	Management practices

[a] The household farmland is the land on which the household exerts a direct control (fields, fallows and secondary forest derived from fallows), including inherited old fallows and forest land of the extended family (under family-based control)

[b] Exploitable trees are trees with a diameter at breast height greater than 80 cm, this being the minimum legal exploitable diameter for several commercial species in Cameroon. Small diameters trees have a diameter between 5 and 30 cm

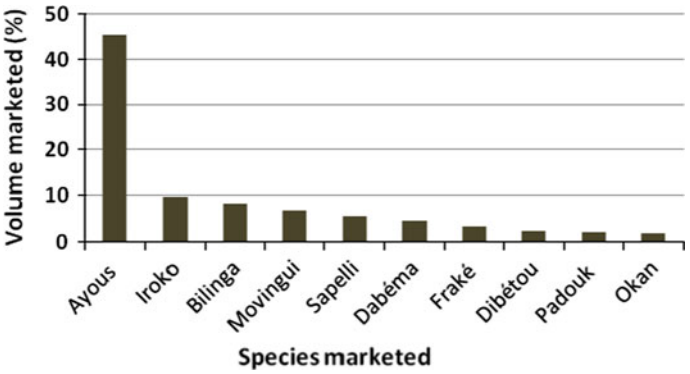

Fig. 2 Ranking by volume of the first ten species sold in the market of Yaoundé. Scientific names of species are provided in Table 3 of Appendix 1

the domestic sector. Five species comprised 75 % of total sales in Yaoundé, with ayous being the most commercialised (about 50 % as shown in Fig. 2).

Logging Operations and Land-use Types

A total of 591 trees were felled in the operations surveyed. The number of trees by operation varied from 1 to 30 (mean = 3.9, stdv = 4.9) with a considerable variability within each land-use category. More than the 43 % of the trees were logged on agricultural land, 30.5 % in fallow-based systems (fallows and annual crops fields) and 13.0 % on cocoa farms (Table 2).

Table 2 Summary of the 151 logging operations, for a total of 591 trees observed

Land-use	Frequency of operations (%)	Trees felled (%)	Number of trees felled per operation (N)		Total number of species felled (N)
			Mean	Stdv	
Old growth forest	30.0	30.0	3.9	4.0	18
Secondary forest	27.0	26.5	3.9	5.8	18
Cocoa farms	14.0	13.0	3.6	6.3	9
Fallow-based systems	29.0	30.5	4.2	3.8	12

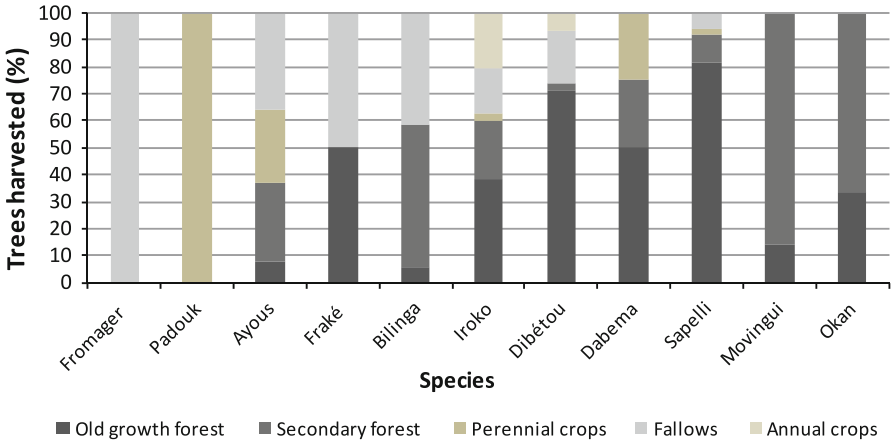

Fig. 3 Percentages of the total number of trees by species harvested in the land-use units. Scientific names of species are provided in Table 3 of Appendix 1

Over a third of the species (36 %) were harvested principally in the agricultural land-use units (Fig. 3). The majority of trees harvested on agricultural land were ayous (60 %) and iroko (21.5 %). Ayous accounted for the 86 % of trees harvested in the perennial tree crops systems and the 60 % in the fallows, while iroko accounted for the 82 % of the trees harvested in the annual crops farms, 16 % in the fallows and the 5 % in the cocoa farms.

Operating costs were lower for timber harvested in the agricultural units, in particular in fallows, than in the forest (Fig. 4).

Timber Trees in the Rural Mosaic

On average each household had 4 fallow plots (stdv = 2.3, min = 1 and max = 11 units). More than one third of the farmers indicated they had only fallows under short rotation (less than 5 years). Of the plots of other households, only 10 % were older than 10 years. The majority of households (75 %) farmed cocoa in small plantations (62 % smaller than 1 ha). About 60 % of the households owned some forest land together with members of their extended family, preserved as a resource for game, NTFPs and timber for family needs.

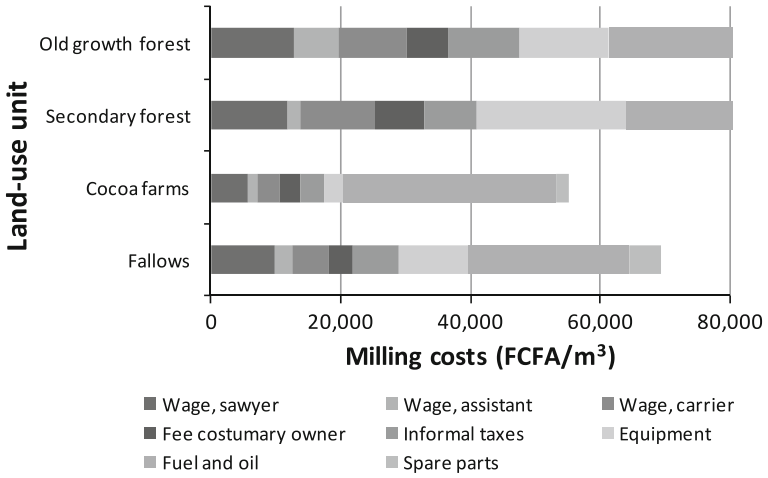

Fig. 4 Processing costs land-use unit (in FCFA/m^3). 1FCFA = 0.0025USD

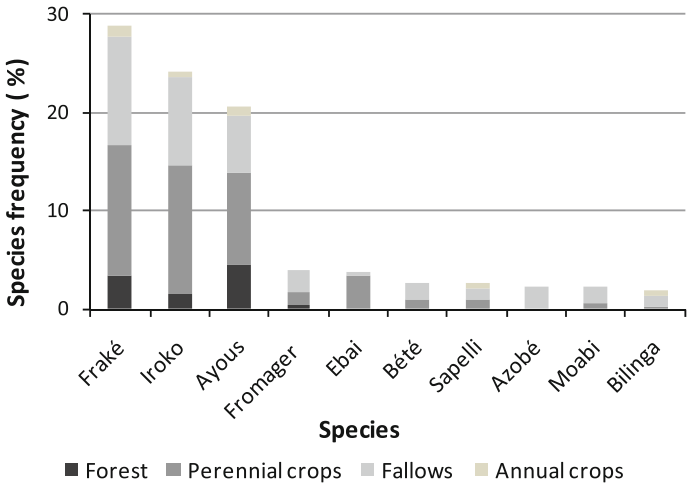

Fig. 5 Relative species frequency by land-use unit as percentage of total individuals declared (N = 1,039). Scientific names of species are provided in Table 3 of Appendix 1

Overall the farmers reported 33 commercial timber species on their farmland. A total of 25 species were reported on fallow land, 23 in cocoa plantations and 18 in secondary and old-growth forest. Only 5 species were found in annual crop fields. Species abundance varied by land-use type, with frake, iroko and ayous the tree species by far the most frequently reported by farmers (Fig. 5). Cocoa agroforests contained the highest number of exploitable trees, followed by fallows.

Only 38 % of the farmers reported the presence of small diameter trees in their farmland. These belonged only to 14 species. Small trees were more abundant and diverse in fallow units (58.2 %, N = 11 species) than in cocoa plantations (35 %,

N = 9 species) and were completely absent from annual crop fields. Ayous was the most frequently reported species, followed by iroko and frake. According to the farmers the causes for shortage of small diameter trees (gaps in regeneration) were repeated weeding practices and harvesting for fuelwood.

Almost 90 % of the farmers indicated that farmland timber resources were dramatically decreasing. About 35 % of farmers reported ayous as the species that had most rapidly diminished, 17 % indicated iroko and 12 % dibetou (*Lovoa trichilioides*). Other species that had become scarce include bubinga (*Guibourtia* spp.), moabi (*Baillonella toxisperma*) and sapelli. Farmers observed that natural regeneration had reduced in particular in fallows.

Timber Tree Functions and Management

About 67 % of farmers declared they attempt to preserve timber trees on their fallows and on cocoa farms. The reasons for maintaining a particular species depended on the land-use type (Fig. 6). The quality of shade provided was the main reason in cocoa agroforests, followed by timber production. Some timber species including frake were preserved to improve soil fertility, and others including moabi, sapelli and padouk, for the production of food or of traditional medicinal products.

Farmers described three main practices used to nurture valuable young trees: controlling fire during field preparation; weeding and thinning; and transplanting naturally regenerated trees. Only 4 % of farmers applied all three methods, the majority using only fire control. Fire control was used almost exclusively in fallow-based systems, with weeding and thinning in cocoa farms to provide sufficient light for cocoa trees. Less than 20 % of the farmers stated they transplant seedlings from fallow units to their cocoa farms and preferentially multi-functional tree

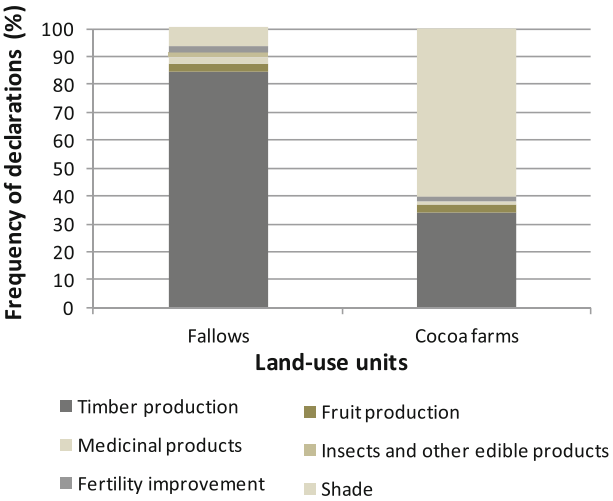

Fig. 6 Reasons for maintaining trees reported by farmers for 15 species in the fallow and cocoa land-use units

species, in particular moabi. The main reason for planting was to conserve the resource for future generations.

Tree Tenure

All the farmers considered that timber tree tenure was vested in the customary land owner. Based on this belief, they exerted individual control of trees growing on the land to which they had exclusive rights: agricultural fields, fallows of short to medium duration and cocoa farms. No differences in tenure of naturally occurring and planted trees were reported. Access to naturally occurring trees in extended family forests and on inherited old fallow land was controlled by the head of the extended family. Any use of or financial transaction of the trees on such land had to be made in agreement with the head and other elders of the family.

Farmers' Perceptions of Small-scale Logging

About 70 % of respondents considered the sale of on-farm timber trees to artisanal sawyers a normal practice and stated they had sold timber at least once in the last 5 years. The remainder reported that timber stocks on their farmland were rare and existing trees needed to be maintained for future generations to avoid the heirs having to purchase timber from outside the village.

According to the farmers, the practice of selling trees to artisanal loggers commenced in the mid-1990s and became common because of the increasing presence of loggers searching for timber in the villages. Prior to this, trees were felled mostly to satisfy family needs for heavy construction timber. It was also possible at this time to purchase high quality sawn-timber products from industrial sawmills in Yaoundé, which have now closed down.

Village chiefs reported a dramatic increase over the last 10 years in the number of chainsaw millers operating in their villages. Two categories of chainsaw millers were distinguished: farmers owning a chainsaw and professional small-scale loggers. In slightly more than 60 % of the villages farmers had their own chainsaw, which they also rented to other farmers, primarily to remove trees for field preparation. At the time of the survey a number of professional small-scale loggers—ranging from 1 to 20 (mean = 4, stdv = 7.9)—were operating in 92 % of the villages. About 60 % of the loggers were native to the village, the rest being from neighbouring villages or from urban areas (30 % from Yaoundé). In 60 % of the villages the timber felled exclusively supplied urban markets in Yaoundé, the remainder supplying also minor urban centres and local users.

Farmers reported that the access of small-scale operators to their farms was never without their consent. They were fully recognized by the loggers as tree owners, and in most cases made the offer to sell timber trees. Preferentially trees were felled in the fallow units (60 % of the fellings reported between 2004 and 2009 inclusive). Most respondents felt however that they had a low level of power in negotiations with the logging operators, complaining about low payments, delays in fulfilling the agreement, poor attention paid to avoiding damage to crops, and the felling of additional trees without their consent.

In general farmers were not aware of the market value of sawn wood, but the increasing pressure of small-scale logging was considered an indicator of its growing economic importance. Trees were sold mostly to cover household unexpected outlays. The fact that timber sale is illegal was not perceived as a barrier to respond to loggers' demand. Most farmers were not familiar with the articles of the forest code governing their customary rights, but because of the troubles experienced with the forest administration (e.g. the confiscation of sawn timber) they were aware of the prohibition on selling trees growing on their farmland. The few farmers (less than 5 %) who were familiar with the code argued the law was unfair, because it prevented them from fully benefitting from their customary tree tenure rights.

Discussion

A key finding of the study is that small-scale logging activities conducted on customary smallholders' land in the NPFE of the Central Region provide a large supply of timber to the national market. The contribution of agricultural land to timber supply is particular large for ayous, although no important commercial species are harvested exclusively from the forest units. Over the last 15 years the small-scale logging sector has benefited from the abundance of timber species in agricultural areas, derived from the long-standing smallholders' tradition of maintaining multi-purpose forest trees in shifting cultivation systems. The match between the abundance of white wood species, including ayous, and its growing demand in the urban markets has favoured the proliferation of small-scale logging practices.

Various factors combine to make logging on agricultural units attractive for small-scale operators—in particular the low operational costs due to availability of timber resources, their accessibility and the ease of felling compared to forest logging. Further, the low bargaining power of individual farmers and lack of knowledge of market value, coupled with their willingness to remove trees from farmland, facilitate the negotiating process and their consent to fell and sell timber for a low price.

Trees are more frequently harvested in the fallow units than in the cocoa agroforests. This may reflect a difference in harvesting intensity due to fallow land being much more extensive than the other land-use types. However, the study reveals that the functions for which tree species are maintained in the agricultural units and their management vary by species and by land unit type, and it is likely that the willingness to remove a tree varies on the same basis. In general, farmers are less protective about trees in fallows because secondary vegetation is traditionally removed to prepare for the next cropping cycle. Felling decisions depend on tree size because farmers take into consideration tradeoffs between short and long-term benefits from trees. On fallow land harvesting of wood for fuel, poles or use in local light construction might be considered as a better alternative than maintaining a tree through repeated fallow cycles until it reaches an exploitable size. These considerations apply most likely in areas where land is scarce, short

fallow rotations are dominant and land for annual crops is needed, as in the Central Region. In areas with lower human pressure and with abundant land, the control on tree resources preserved in old fallows may not be secure in the long term because with the ageing of the fallow vegetation and development of secondary forest, individual household rights merge into extended family rights (Diaw 1997).

A different strategy from the one described for fallows applies to trees on traditional cocoa farms that are *quasi*-private household land (Weber 1977; Burnham 2000). Farmers keep the small diameter tree density deliberately low to allow sufficient light for the cocoa, and introduce and preserve multi-purpose trees. The survey findings suggest that farmers are reluctant to fell large diameter trees because each single tree on the farm plays a socio-economic role (for production of NTFP) and an ecological role (e.g. enhancement of soil fertility and shading needed by the agroforestry system), but also to prevent a reduction of cocoa production caused by falling trunks and branches.

The Ecological Impact of Small-scale Logging on Timber Species Availability in the NPFE

Ayous is a characteristic tree of the original semi-deciduous forest in the region. It is a light-demanding species that regenerates well in agricultural forest gaps and colonizes secondary evergreen forests (Letouzey 1985). Originally farmers preserved it for the quality of the shading and leaf litter, considered to improve fertility (Carrière 1999; Bidzanga 2005). Very large individual trees were not removed because of the lack of appropriate means. As argued by Carrière (1999), it is likely that in the long term the preservation of adult trees on farms has favoured spread of this species in the rural land. The same may apply for the other light demanding species typical of the semi-deciduous forest in the region, including frake, fromager and iroko. It is known that forest trees on farm land play an important role in conserving forests. At the plot level they function as seed sources, feeding and perching sites for dispersal by birds and small vertebrates (da Silva et al. 1996; Duncan and Chapman 1999), and provide favourable conditions of light, moisture and nutrients for tree regeneration (Uhl 1987). At the landscape level they enhance connectivity and perform a conduit function for forest species across the agricultural mosaic. Ultimately, the ecological benefits of on-farm forest trees go beyond the rural mosaic and extend to the forest margin, mitigating the effects of forest loss due to the agricultural expansion.

In the long term unregulated small-scale logging reinforces the negative effects of fallow shortening and agricultural expansion on forest tree species abundance (Robiglio and Sinclair 2011). The removal of trees of reproductive age drastically reduces the seed rain in farmland and in the surrounding forest, undermining the regeneration processes of forest species in the natural fallow units, already weakened by recurrent fire, weeding and clearing during the cropping cycle (Norgrove et al. 2000). By contributing to the degradation of the fallow matrix, artisanal logging on agricultural land indirectly increases the margin and isolation effects in the remnant forest patches, exacerbating their degradation processes (Ewers and Didham 2006).

The Management of Farmland Timber

Agricultural expansion and intensification with adoption of new crops and sun-loving varieties, coupled with technological changes including the use of chainsaws to clear land for farming, is likely to accelerate removal of trees from the rural mosaic, as already observed in the cocoa producing areas of Ghana by Ruf (2011). Whilst in the short term this will certainly boost the flow of small-scale logging timber towards the urban market, in the long run it might seriously jeopardize timber availability, particular for the most demanded species. To avoid negative socio-economic impacts in areas where small-scale logging is positively contributing to livelihoods, and in the perspective of legalizing it, there is the need to design sustainable management options for farmland timber resources.

A first step towards the identification of sustainable management options is to quantify actual timber stock, and to understand its species composition, variability and the factors controlling it. Particular attention is needed on the fallow units that constitute a huge reserve of land and are managed with greater flexibility than the cocoa farms. The assessment of timber availability can provide a preliminary indication upon which exploitation can be regulated in the short term. Among the 51 commercially valuable species indicated by MINEF (1995), particular attention should be paid to the secondary species that the government has committed to promote in the domestic timber market (MINFOF-MINCOMMERCE 2010). The diverse range of species available in older fallow units and on cocoa farms highlights the opportunity for increasing the diversity of the farmland timber sold.

Tree planting and enrichment schemes need to be developed in order to maintain long-term production options. Considering the strong support given to agricultural development by the Cameroonian government, measures to combine agriculture and timber production are needed which target smallholders as the main actors in the design of integrated systems. Initiatives already exist in Anglophone Africa such as the 'Modified Taungya System' and timber-cocoa associated systems in Ghana (Agyeman et al. 2003). Their outcomes and suitability in the Cameroonian smallholder context require evaluation against multiple ecological, socio-cultural, livelihoods and governance criteria.

Several positive factors are apparent when considering smallholder timber production. Valuable timber species are available and are already part of farmers' land-use systems. This implies a wealth of local knowledge about species management and integration into agroforestry (e.g. Bidzanga 2005), and about uses that could be associated with timber production to provide increased benefits. Indigenous timber species are adapted to the environment and contribute to mitigation of forest degradation and increased forest ecosystem system resilience. Moreover, for the species classified as vulnerable in the IUCN RED list of threatened species (sapelli, iroko, padouk and azobe), on-farm nurturing would contributes to in situ conservation strategies.

Many challenges lie ahead to ensure a long-term contribution of farmland trees to sustainable management of national timber resources. The first challenge is to make timber production a realistic, long-term livelihood option, to encourage farmers to shift from opportunistic exploitation of timber resources to their management,

including planting and enrichment in fallow land. The results of the present study suggest that options to secure benefits from the sale of trees and timber should be explored. These might range from the recognition of full tree ownership to the formulation of schemes that integrate short and long-term payoffs. Farmers should be formally included in the timber sector as tree owners and producers. The increasing sale of trees and growth in the number of chainsaw owners in villages are signals that farmers in the Central Region of Cameroon are gradually entering the timber sector. However, a large gap exists between the compensation farmers receive from timber sale and the timber value in the domestic market (Cerutti and Lescuyer 2011). The gap becomes huge if export values are considered (Gockowsi et al. 2010; Ruf 2011). Gockowski et al. (2010) and Ruf (2011) suggested that information about market prices would encourage farmers to consider timber as a valuable product to associate with cocoa. However, the impact of a possible rise in the fees paid to tree owners on the economic competitiveness of small-scale logging needs to be assessed and scenarios for market evolution simulated to identify the feasibility, potential and risks of encouraging farmland tree management and of an increase of timber price.

Beside changes in policies and legislation this study highlights the need for capacity building in the management of timber resources because farmers have not yet developed any specific form of silvicultural management of their trees for timber production. Prescriptions about timber species management, based on local and technical knowledge, need to be developed and disseminated. Farmers will also need technical support in producing tree seedlings for species of market interest, or be trained in domestication procedures of species to overcome their reliance on natural regeneration.

Conclusions

Over the last 15 years tree stock originating from traditional on-farm tree management practices has largely sustained the growing demand for timber in Cameroon. Ayous has been the main species logged, being sourced in particular from fallow land and cocoa farms. Exploitation of timber resources on rural land in the NPFE is strongly linked to agricultural management practices. However, uncontrolled small-scale logging in association with agricultural intensification and expansion undermines future timber availability in the NPFE. Long-term strategies to sustain national timber production should thus be devised by policy-makers, with a focus on the legalization of a sustainable small-scale logging sector, in order to decrease the risk of a timber shortage in agricultural land in the regions where artisanal loggers traditionally operate. One option is to maintain and further promote the strong association between small-scale logging and agricultural land use, with positive benefits for logging operators and smallholder farmers and enhancement of environmental services provided by forest trees in the agricultural matrix. The traditional use and maintenance of trees in farm mosaics is evidence that smallholder farmers are adept at integrating trees into agricultural practices. However, strategic policies are needed to counteract present barriers to on-farm

timber production, traversing the forestry and agricultural sectors, together with regulations that recognise timber rights, and legalise and optimise the benefits that farmers derive from timber harvesting.

Acknowledgments The study on farmland trees was funded by the Fellowship Programme of the International Tropical Timber Organization (Ref. No. 071/04A) and hosted by the Central Africa Regional Office of the Center for International Forestry Research (CIFOR). Data collection was also funded by the Dutch Directorate General of Development Cooperation (DGIS) 'Illegal logging in Cameroon and Gabon: The international FLEGT process, national trends and local impact' project, and the European Union financed the 'PRO-Formal: Policy and regulatory options to recognise and better integrate the domestic timber sector in tropical countries in the formal economy' project. Technical support from IFAD is also acknowledged. The views expressed do not, in any way, reflect the official position of the ITTO, IFAD, the European Union, DGIS or CIFOR. We thank Anne Branthomme from FAO for the access to the MINFOF-FAO Inventory data, and Diomede Manirakiza, Joachim Nguiebouri, Edouard Essiane Mendoula and Jean-Pamphile Ondoua for data collection.

Appendix 1

Most marketed timber species in Cameroon

The FAO-MINFOF Inventory was used to obtain data about the species that are most marketed in Cameroon. For each species, volume and stand density were calculated for 80 plots covering the non-old growth forest classes in the inventory (i.e. the young secondary forest and agricultural areas) in Stratum 1, corresponding to the humid forest zone in Southern Cameroon. The total sampled area considered was 160 ha and included 85.42 ha of rural mosaic (Figs. 7, 8).

See Table 3.

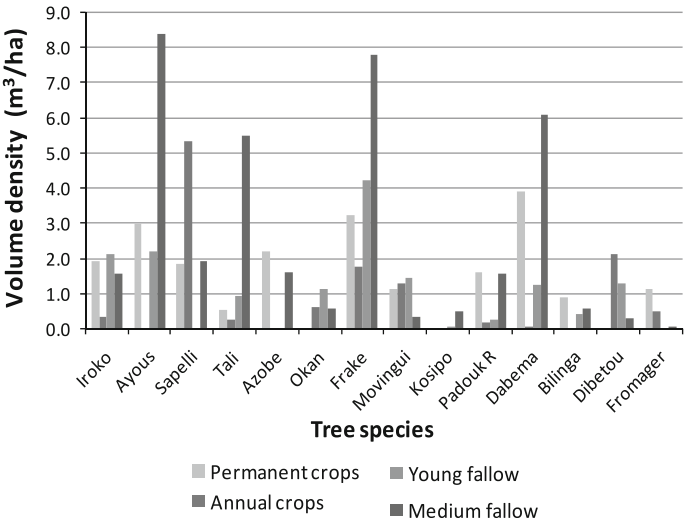

Fig. 7 Estimated volume density of the most important commercial species in the Cameroon export and domestic sectors. Derived by the authors from inventory data in FAO–MINFOF (2007)

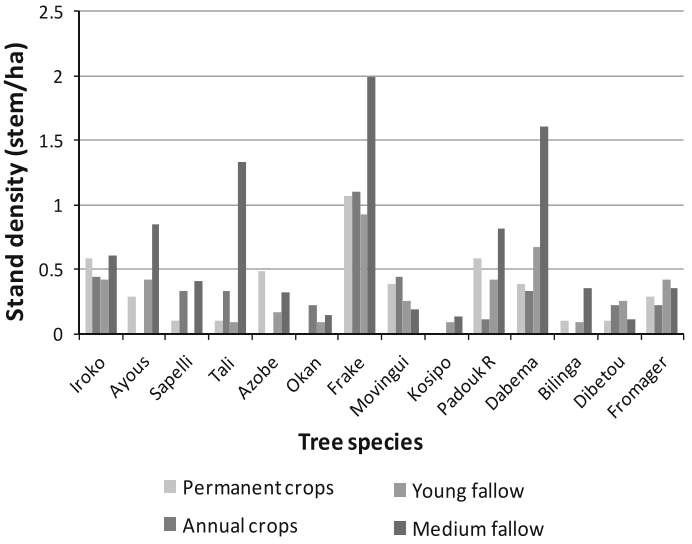

Fig. 8 Estimated stand density of the most important commercial species in the Cameroon export and domestic forest sectors. Derived by the authors from inventory data in FAO–MINFOF (2007)

Table 3 Main commercial tree species in Cameroon

Commercial name	Scientific name
Ayous	*Triplochiton scleroxylon*
Azobe	*Lophira alata*
Bilinga	*Nauclea diderrichii*
Dabema	*Piptadeniastrum africanum*
Dibetou	*Lovoa trichilioides*
Frake	*Terminalia superba*
Fromager	*Ceiba pentandra*
Iroko	*Milicia excelsa*
Kosipo	*Entandrophragma candollei*
Movingui	*Distemonanthus benthamianus*
Okan	*Cylicodiscus gabonensis*
Padouk rouge	*Pterocarpus soyauxii*
Sapelli	*Entandrophragma cylindricum*
Tali	*Erythrophleum ivorense*

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